Spawning and Development in the Trochid Gastropod *Euchelus gemmatus* (GOULD, 1841) in the Hawaiian Islands

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(2 Text figures)

THE PURPOSE OF THIS PAPER is to describe the breeding habits and development of the trochacean gastropod *Euchelus gemmatus* (GOULD, 1841) in the Hawaiian Islands. There are no previous reports of spawning periodicity or laboratory observations on the spawning behavior of a tropical trochid.

Euchelus gemmatus is a small (2 to 4 mm in height) trochid which is common in shallow water along the shorelines of the Hawaiian Islands. Large populations of this animal occur on the lower surfaces of dark, mottled rocks in tidepools and in shallow offshore waters where there is moderate turbulence. The snails are usually found congregated in crevices and beneath algae, but they are also able to cling to exposed rock surfaces.

METHODS

Forty animals averaging 2 to 4 mm in height were collected in October, 1965, and maintained in 2 one-gallon containers, 20 in a non-aerated jug and 20 in a container in which the turbulence of the natural habitat was simulated by means of an air stone. The animals were maintained in both situations for a period of 2 years and spawning and development occurred equally well among snails in both containers.

Egg masses which were deposited on the glass walls of the containers were removed by means of dissecting needles and placed on microscope slides which were set on a stand in a finger bowl. The egg masses were then easily removed for microscopic examination and could be replaced without injury. Daily changes of sea water and a soft jet of air bubbles directed onto the egg masses increased the survival rate of the developing embryos by reducing the numbers of ciliates which often congregate about the egg masses.

SPAWNING HABITS

Spawning in *Euchelus gemmatus* occurs from late December through April. The beginning of the spawning period is marked by the secretion of a gelatinous coat over the surface of the female shells; the covering remains on the shells throughout the spawning period. Subsequent to the appearance of the coat, pair formation occurs, a smaller male becoming attached to the left apertural sur-

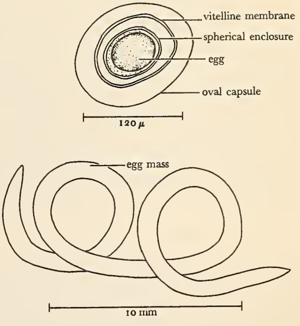

Figure 1

Euchelus gemmatus (GOULD, 1841)
Egg capsule and egg mass

face of the female shell. Because trochids presumably do not copulate, it is suggested that the male's position near the aperture of the female shell permits gametes to pass into the mantle cavity of the female.

During the period of observation 13 egg masses were deposited on flat surfaces from 1 to 5 cm above the surface of the water; the egg masses were deposited at twilight and at the time of high tide, with 9 of the egg masses deposited in March at the time of "extreme" high tide. After the initial spawning of one or two pairs of trochids, the remaining pairs spawned with increasing frequency.

Although it was difficult to observe egg deposition because of the initial transparency of the egg mass, it was possible to see the general pattern. Each female moves over a path about 15 mm in length in a counter-clockwise direction, depositing the egg mass (Figure 1). The egg masses are 3 to 14 mm in length, 2 to 3 mm wide, and about 1 mm thick, and they are deposited in the form of 3 to 5 loops. Females with smaller shells produce masses with fewer loops. The egg masses are flexible, jelly-like structures, enveloped by a thin, transparent integument which becomes translucent within an hour after deposition. The wall of the mass is tubulate and several layers of egg capsules are contained within the translucent matrix except at the tapered tips of the loop.

The eggs are brown and spherical, about 50μ in diameter. Each egg is surrounded by a relatively homogenous sphere of albumen-like material, that nearest the egg semi-fluid and clear, the remainder more viscous. The egg and semi-fluid material are in turn surrounded by the vitteline membrane which is contained within a spherical elastic enclosure suspended in an outer oval capsule (Figure 1). The elastic enclosure stretches slowly as the embryo develops, exhibiting a fibrillar appearance. Prior to hatching, when the envelope is ripped by the embryo, the elastic enclosure almost fills the outer capsule. The capsules, which are closely packed within the matrix of the egg mass, are irregularly shaped because of crowding.

DEVELOPMENT

Early cleavage is initiated immediately after the egg mass is deposited. The first 2 cleavages are equal and occur within a few hours at a water temperature of 23° C. Subsequent cleavages result in the formation of large macromeres and small micromeres which envelop the macromeres, giving rise to the blastula within 2 days. A ciliated gastrula, which is flattened at the poles, develops during the next 2 or 3 days. The eggs at the surface of the egg mass are generally more advanced than are those near the center of the matrix.

The trochophore is recognizable 2 to 4 days after the egg mass is deposited and persists within the egg capsule for 3 to 5 days. The velar lobes are lightly pigmented and, although ciliated, the only noticeable motion is a slight vertical vibration. In the dorsal region a thickened clump of cells, the shell gland, becomes visible, and by the end of the third or fourth day this area of the embryo is covered by a thin sheet of shell matrix. The shell expands, occupying about $\frac{3}{4}$ of the dorsal surface, in a trochophore ready to metamorphose. Anterior and ventral to the visceral mass are 2 large, rounded protuberances which fuse, forming the foot of the veliger. As the foot develops, statocysts form as 2 elongated depressions behind the region of the mouth. There are 7 to 12 vibrating, calcareous grains in each statocyst, which gradually "sink" into the foot and are covered by pedal tissue. Rudiments of eyes, as 2 dark pigmented areas, are also visible at this period.

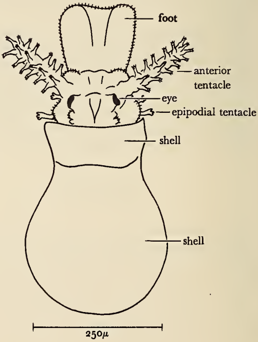

Figure 2

Euchelus gemmatus (Gould, 1841)
Dorsal view of the late veliger stage

The veliger becomes recognizable 3 to 9 days after spawning, with a cap-like shell and anteriorly projecting foot (Figure 2). There is now a series of 5 protuberances: 3 small protuberances from which develop the epipodial tentacles and 2 larger protuberances which develop into the large anterior tentacles. Each protuberance has a concentration of cilia about it, moving more or less in a counter-clockwise direction.

The visceral hump with its cap-like shell slowly shifts posteriorly, and torsion occurs within the next 24 hours. The shell seems to be deposited by the mantle as a thin translucent covering. Shortly after the translucent covering has been deposited, a shingle-like layer is deposited and continues to develop, soon occupying the entire dorsal surface behind the prototroch. On the posterior side of the foot a thin functional operculum develops, which in a short time is large enough to close the aperture of the shell. The operculum is first laid down as a series of "cellular" blocks which fuse and ultimately form the "true operculum." At the same time, the shell, which was very thin, becomes thicker and calcareous, with a furrowed surface.

As early as the second week of development, the veliger is seen actively moving about in the fluid of the egg capsule. The movement is generally limited to extending and quickly retracting the foot into the shell. The retractive response seems to be associated with changes in light intensity and slight external vibrations. Shortly after, when the albumen-like material is gone, the veliger becomes very active and rips the egg capsule with its radula, leaving as a semi-crawling larva. Though the larvae are capable of darting movement, they remain relatively inactive, their movement localized to midway on the sides of the container. The larvae grow to 2 mm in height and, as the next breeding season approaches, the snails pair up and begin moving up and down the sides of the container with the times of the tides, laying egg masses in the same fashion as their parents.

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